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2,448,007

SELF-CONTROLLED PROJECTILE

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2 Sheets-Sheet 2

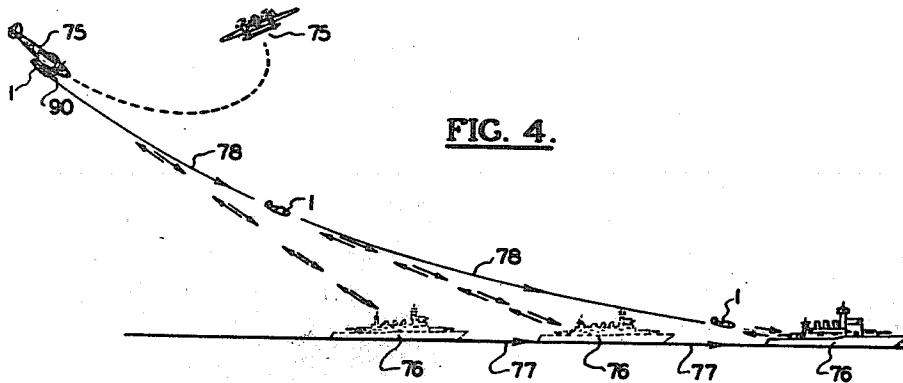


FIG. 4.

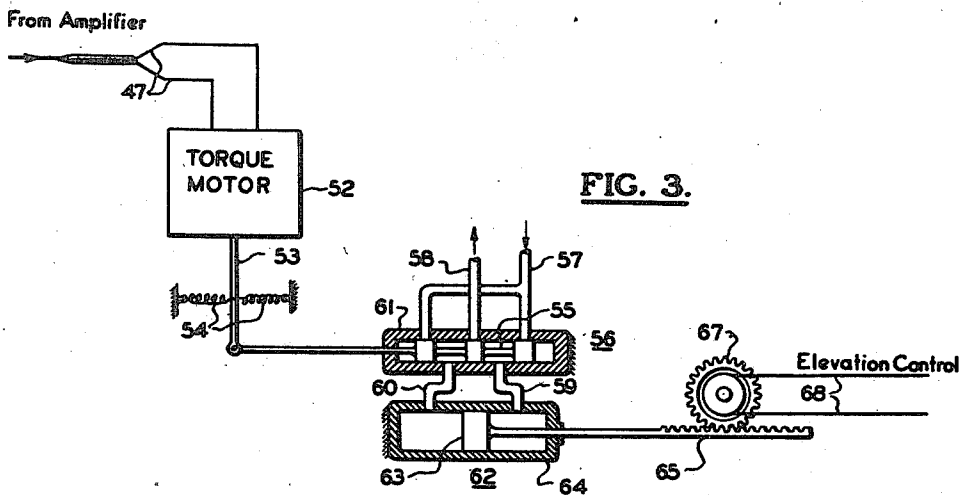


FIG. 3.

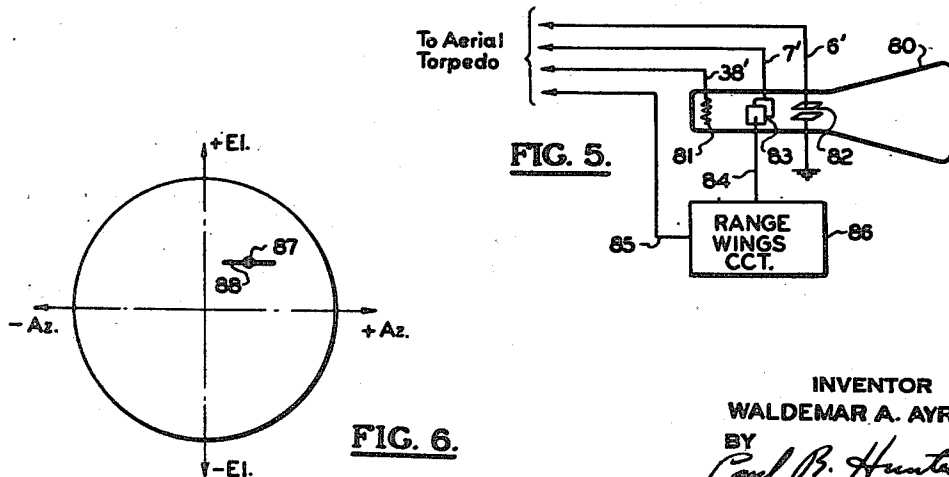


FIG. 5.

FIG. 6.

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SELF-CONTROLLED PROJECTILE

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Application January 8, 1943, Serial No. 471,781

9 Claims. (Cl. 244—14)

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The present invention relates generally to means for and methods of striking a stationary or moving object with a target-seeking high explosive charge, and the invention has reference more particularly to a novel explosive-bearing and self-steering body adapted, upon being initially directed substantially along the line of sight to a target, to continuously maintain its direction of motion along said line of sight, even as the same changes, and so to strike the target.

All commonly known explosive-bearing bodies designed to strike and explode against a target such as bombs, gun projectiles, torpedoes, etc., have fixed time-space relationships, or trajectories, from the moment they leave their associated control apparatus. The control apparatus associated with such explosive-bearing bodies ordinarily includes radio or optical means for defining a line of sight to the target and obtaining target range, and also some kind of predicting and computing mechanism. This predicting and computing mechanism attempts to predict the future position of the target from the behavior of the present position, and then computes the initial direction of motion which must be imparted to the explosive-bearing body in order that its fixed and known trajectory will intersect the target at the predicted future position.

Obviously, in determining what the initial course of the controlled body should be, the predicting and computing mechanism can only take into account the conditions existing up to the time the body leaves the control apparatus. Therefore, any unpredictable variations from the initial known conditions, such as changes in the target's course or speed, which occur during the flight of the body, necessarily result in the explosive-bearing body missing the target, since no control is exerted over the body after it leaves the control apparatus.

The probability of a material variation in the initial conditions occurring during the time of flight obviously can be reduced by decreasing the time of flight, that is, by approaching closer to the target before the body is allowed to follow its own predetermined trajectory. However, such a procedure is sometimes impractical and always dangerous. For example, the closer a torpedo plane is flown in toward the target before its torpedo is released, the greater is the probability of a hit, but the greater also is the possibility that the torpedo plane, itself, will be hit by anti-aircraft fire from the target either before or after the torpedo is released.

In the present invention it is proposed to mount

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on an explosive-bearing body its own control apparatus whereby its direction of motion may be continuously controlled throughout its time of flight. In this way the body may be released at a point so far removed from the target as to be out of range of its defensive weapons. Moreover, since the direction of motion of the body may be continuously compensated for changing conditions right up until the time that the body strikes the target, it would seem that an extremely high percentage of hits could be expected.

In the present application the inventor has exemplified his invention as a target-seeking aerial or glider torpedo adapted to be released from a carrier aircraft. The carrier aircraft need only be equipped with means for defining a line of sight to the target so that an initial direction of motion substantially along the line of sight may be imparted to the aerial torpedo. The aerial torpedo itself is equipped with radio means for defining a line of sight, and means for sensing and deriving signal voltages proportional to the deviation of its own direction of motion with respect to the line of sight, both in elevation and azimuth. In addition, there is included in the equipment mounted on the aerial torpedo a servo control system, responsive to said deviation, or error, signal voltages, and actuating the control surfaces of the torpedo in the proper sense to reorient the torpedo along the line of sight to the target, thus reducing the signal voltages to zero. In this way the aerial torpedo is continuously aimed or directed toward the target and made target-seeking, and must eventually strike and explode against the target. In one embodiment of the invention, information obtained from the radio sighting apparatus mounted on the aerial torpedo is transmitted to the carrier craft thus eliminating duplication of sighting means.

Accordingly, the principal object of the present invention is to provide a self-steering target-seeking and explosive-bearing body adapted to steer itself into and explode against a predetermined target.

Another object of the invention is to provide, on an explosive-bearing body, automatic means for controlling its direction of motion so as to strike and explode against a predetermined target.

A further object of the invention is to provide a self-steering and explosive-bearing body adapted, upon being initially directed along the line of sight to a target, to automatically main-

tain its direction of motion along said line of sight to said target even as the same shifts.

A still further object of the invention is to provide an aerial or glider torpedo adapted upon being released from a carrier craft in the general direction of a target, to continuously and automatically control its own trajectory so as to intercept the target.

A still further object of the invention is to provide means for enabling an aircraft pilot to strike a target with a high-explosive charge adapted to be released from said craft.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawings wherein the invention is embodied in concrete form.

In the drawings,

Fig. 1 is a schematic drawing illustrating a preferred embodiment of the present invention.

Fig. 2 is a front elevation view of the aerial torpedo.

Fig. 3 is a schematic representation of the servo system of Fig. 1.

Fig. 4 is a diagram illustrating the instantaneous angular and spatial relationships of the aerial torpedo with respect to the target at three successive stages in the flight of the aerial torpedo.

Fig. 5 is a schematic representation of apparatus mounted on the carrier aircraft in one embodiment of the invention.

Fig. 6 is a drawing of a typical presentation appearing on the face of the cathode ray tube of Fig. 5.

Similar characters of reference are used in all of the above figures to indicate corresponding parts.

Referring now to Fig. 1, there is shown a target-seeking aerial or glider torpedo 1 and its associated control equipment, all of which will be understood to be mounted on the aerial torpedo. The aerial torpedo 1 is equipped with the steering or control surfaces of an ordinary glider, that is, the elevator 2, rudder 3, and ailerons 4. As shown in Fig. 2, the aerial torpedo 1 is provided with wings having considerable dihedral in order to insure stability of the torpedo about its normally horizontal fore and aft axis. If desired, the required lateral stability could alternatively be obtained by the provision of a horizon gyro adapted to produce signal indications corresponding to any rotation of the torpedo about its fore and aft axis. A conventional horizon gyro of the type used in well-known automatic pilot systems could be employed for this purpose. These signals could then be employed through a suitable servo system to provide an aileron control, which control would be superimposed upon the banking angle control of the ailerons which is hereafter described.

The associated control equipment of the aerial torpedo 1 may be conveniently divided as to function by the dash line 5-5, as shown in Fig. 1, the apparatus above the line 5-5 serving to define a line of sight to the target and to produce on leads 6 and 7 voltage error signals indicative of the angular displacement of the glider axis with respect to the line of sight, and the apparatus below the line 5-5 serving to control the direction of motion of the glider so as to reduce the error signals to zero and thus maintain the glider continuously directed toward the target.

The upper portion of the equipment, that is, the line of sight defining system, is illustrated as a reflected-pulse type of ultra high frequency

system of the kind employed for tracking purposes in copending application Serial No. 441,188, entitled Radio gun control system, and filed April 30, 1942, in the names of C. G. Holschuh et al., although any radio system adapted to define a line of sight and produce voltage signals proportional to the elevation and azimuth thereof could as well be used. As described in that application, a control oscillator 8 provides a voltage of suitable synchronizing and control frequency which may be in the audio range. The output of control oscillator 8 is connected, as by lead 9, to a pulse generator 10 which converts the substantially sinusoidal oscillations fed to it into pulses of any desired shape, magnitude, and duration, having a repetition rate equal to the frequency of oscillator 8. This device employs well-known clipping, differentiating, and other suitable wave-shaping circuits in the conventional manner and consequently seems to require no further explanation.

The pulse generator 10 supplies trigger pulses to a pulse transmitter 12, as on lead 11, causing an ultra high frequency oscillator, included within the pulse transmitter 12, to be biased on momentarily. Transmitter 12 is thus caused to produce extremely short pulses, of perhaps one micro-second duration, of carrier frequency, which pulses are fed through wave guide 13 to a scanning radiator 14.

The scanning radiator 14 may be a simplified version of the type disclosed in copending application Serial No. 438,398, for Scanning devices, filed April 10, 1942, in the names of Hall Langstroth and Fred C. Wallace, now Patent 2,407,305 granted September 10, 1946. The radiator described in that application is adapted to first perform a spiral scanning motion for searching purposes, and then perform a conical scanning motion for tracking purposes. The spiral scanning is accomplished by rotating the radiator about a spin axis and at the same time nodding the parabolic reflector at a slower rate about a nod axis perpendicular to the spin axis. The conical scanning is accomplished by simply stopping the nodding motion at a small angle from the zero nod position of the reflector, while continuing to rotate the radiator about the spin axis. Since in the present invention it is only required to produce conical scanning for tracking purposes, the axis of the reflector may be permanently offset at a slight angle from the spin axis. In this case, therefore, no mechanism is required to produce a nodding motion.

The radiator 14 is shown in Fig. 1 in simplified form in order to clarify the basic mechanism. As there shown, a parabolic reflector 15 is mounted on a hollow supporting column 16, which column in turn is supported upon a rotatable base (not shown). Column 16 and reflector 15 are adapted to be rotated about a spin axis 17 by the fixed motor 18 through gearing 19 and 20. Because of the bend in column 16, the axis 21 of the reflector 15 will then describe a cone about spin axis 17, thus providing the required conical scanning. It will be understood that the radiator 14 is mounted in the aerial torpedo 1 so that the spin axis 17 coincides with the axis of the aerial torpedo.

The rotation of column 16 and reflector 15 about the spin axis 17 is transmitted, as by gearing 22 and shaft 23, to a two-phase generator 24 which is adapted to produce on its output leads 25 and 26 two 90° phase-displaced alternating current voltages, thus providing a time reference for the spin motion. In this way, the in-

stantaneous magnitude of the voltage 26 may be made to correspond at any time to the elevational component of the angle that the reflector axis 21 makes with the spin axis 17. Similarly, the instantaneous magnitude of the voltage 25 corresponds to the azimuthal component of that angle.

The ultra high frequency pulses, originating in pulse transmitter 12 and propagated along the wave guide 13, enter the radiator 14 through the cylindrical wave guide 27. They are then transmitted to the deflecting plate 30 through the rotating joint 28 and a second cylindrical wave guide 29 mounted concentrically within the hollow column 16. The deflecting plate 30 is adapted to interchange energy with the reflector 15 so that a fan-shaped beam of electromagnetic energy is intermittently projected into space along the axis 21 of the reflector 15. Thus, as the reflector 15 spins about the axis 17, the electromagnetic energy is irradiated into a solid conical angle of space.

Radiator 14 serves also to receive energy reflected from remote objects during the intervals between successive transmission periods. The received energy passes in reverse direction through the wave guides associated with the radiator 14. A wave guide 13' connected with the wave guide 27 conducts the received energy through a limiter 34 and wave guide 35 to a receiver and detector 36.

The limiter 34 prevents the high-powered transmitted pulses from affecting the receiver, while allowing the relatively weak received energy to pass through with little attenuation. This limiter may be of the gaseous discharge type known to the art, which consists of a gas-filled resonant chamber containing electrodes and maintained close to the ionization point. The limiter is adapted to discharge when strongly excited by the transmitted pulses and thus effectively damps the exciting oscillations. The electrical length of the wave guide 13' is adjusted to reflect a very high impedance to the transmitted pulses at its junction with wave guide 13 when the transmitted pulses, upon attempting to pass through the limiter, discharge the resonant chamber and create substantially a short circuit therein.

The receiver 36 amplifies and detects the received pulses in the usual manner and transmits the detected pulses to the detector and filter 37, as by lead 38. To further insure that no transmitted pulses directly affect the receiver, suitable blanking pulses may be furnished, as on lead 40, from the pulse generator 10 in order to bias the receiver to insensitivity for the duration of the transmitted pulses.

As more completely described in the aforesaid copending application Serial No. 441,188, should an object or a target be within the range of the conical scanning performed by radiator 14, a reflected pulse will be received back corresponding to each transmitted pulse. Also, these reflected pulses will vary in amplitude at the spin frequency, the maximum amplitude occurring at the time that the reflector axis 21 most nearly coincides with the line of sight to the target, and the amplitude of the spin frequency variation being proportional to the amount of angular deviation of the line of sight with respect to spin axis 17. Thus, the detected pulses appearing on lead 38 provide an inherent indication of the amount and direction of the angular deviation of the line of sight to the target with respect to the spin axis 17.

The detector and filter 37 is adapted to produce

on output lead 41 a spin frequency voltage corresponding to the envelope of the pulses appearing on lead 38. This spin frequency voltage 41 is transmitted to the elevation phase sensitive amplifier 42 and the azimuth phase sensitive amplifier 43, as on leads 44 and 45, respectively.

The elevation phase sensitive amplifier 42 is adapted to compare the phase of the voltage received on lead 44 with the elevation reference voltage received on lead 26, and to produce on output lead 6 a direct voltage corresponding in polarity and magnitude to that component of voltage 44, which is in phase with the reference voltage 26. In a similar manner, the azimuth phase sensitive amplifier 43 produces on output lead 7 a direct voltage corresponding in polarity and magnitude to that component of the voltage 45 which is in phase with the azimuth reference voltage 25. Thus, it will be seen that the voltages produced on output leads 6 and 7 correspond in polarity and magnitude to the elevation and azimuth components, respectively, of the error angle, that is, the angle that the line of sight makes with the spin axis 17 and consequently with the axis of the aerial torpedo 1.

The elevation error signal voltage on lead 6 is amplified in elevation amplifier 46 and then transmitted, as on lead 47, to the elevator servo system 48. Similarly, the azimuth error signal voltage on lead 7 is amplified in azimuth amplifier 49 and transmitted to the rudder servo system 50, as on lead 51. The rudder servo system 50 may be of the type shown and claimed in the allowed application of Carl A. Frische and Gerald N. Hanson, Serial No. 206,984, filed May 10, 1938, for Aircraft automatic pilot with automatic banking, which has matured into Patent No. 2,380,425, granted July 31, 1945.

In Fig. 3 there is illustrated a suitable type of rudder and elevator servo system. As has previously been pointed out, the amplifier 46 is adapted to produce in its output lead 47 a reversible polarity direct voltage. This voltage 47 controls a suitable torque motor 52 of any conventional type adapted to produce an angular displacement of its output member 53 in a direction and of a magnitude corresponding to the polarity and magnitude of the control voltage 47.

As shown, output member 53 may be centralized by suitable springs 54 which also assure a linear and a proportionate type of control. Output member 53 is adapted to reciprocate the control piston 55 of a suitable control valve 56 which is supplied with hydraulic or pneumatic pressure from a suitable pump (not shown), as by duct 57, and is connected to a return reservoir or sump by a duct 58.

Valve 56 is adapted to produce between its output ducts 59 and 60 a differential fluid pressure corresponding in sense and magnitude to the relative displacement between its piston 55 and its fixed housing 61. This differential pressure is led to a servo motor 62 having a movable piston 63 and a fixed housing 64. The differential pressure causes piston 63 to move, thereby causing the rack member 65 to be displaced at a velocity proportional to the displacement of control piston 55 and, therefore, also proportional to the control voltage in leads 47 and 6.

It will be understood that the type of servo system illustrated in Fig. 3 could be replaced by any suitable type of servo system adapted to produce a displacement of rack 65 at a velocity proportional to the control voltage 47. If desired, a servo system employing well-known anti-

hunt and anti-lag features could be used. The rudder servo system 50 operates in a similar way to produce a displacement of its output rack member 66 at a velocity proportional to control voltages 51 and 7.

The displacement of rack 65 is transmitted through the pinion 67 to the pulley system 68 which controls the movement of the elevator control surface 2 of the aerial torpedo 1, as schematically indicated by the dash line 69. Similarly, the displacement of rack 66 is transmitted through the pinion 70 to the pulley system 71 which, as indicated schematically by the dash line 72, controls the rudder control surface 3. The aerial torpedo 1 is schematically shown as having its ailerons controlled automatically from the rudder control system 71, 72 through the control device 73. The control device 73 is adapted to modify the rudder control displacement so as to provide the control displacement for the ailerons 4 necessary to produce the proper banking angle for the aerial torpedo 1.

If desired, a separate and independent banking angle control for the ailerons could be provided. Such a control could consist of a servo system and associated equipment similar to the elevator servo system 48, and also a pendulum device for controlling the servo system. The pendulum device would be of the well-known inductive pick-off type adapted to produce a control voltage corresponding in sense and magnitude to the banking angle error.

In Fig. 4, the angular relationship of the aerial torpedo 1 with respect to its carrier aircraft 75 and the target 76 during successive stages of its actual operation is illustrated. The carrier aircraft 75 may be provided with data indicative of the orientation of the line of sight with respect to the aerial torpedo, from the radio sighting means mounted on the aerial torpedo, as will be more fully described hereinafter, or it may be equipped with its own sighting means, which may be either of the radio or optical type. Having picked out a target, the pilot then flies the carrier aircraft 75 toward the target, thereby aligning both the axis of the carrier aircraft and that of the aerial torpedo 1 with the line of sight. The pilot then, having energized the control apparatus mounted on the aerial torpedo 1 by switching means (not shown), releases the aerial torpedo by suitable release mechanism, schematically indicated at 90, which may be of the type commonly used for releasing bombs or ordinary torpedoes.

Thus, the aerial torpedo 1 will have an initial direction of motion imparted to its substantially along the line of sight to the target 76. Accordingly, the target will initially be located within the solid conical angle scanned by the radiator 14, and the control apparatus mounted on the aerial torpedo will operate to maintain the axis of the torpedo coincident with the line of sight throughout the subsequent flight, in the manner previously explained. Thus, as the target follows the path 77, the aerial torpedo 1 will follow a trajectory 78, as shown, such that at any time the line of sight forms a tangent to the trajectory 78. Obviously, if the speed of the aerial torpedo 1 is sufficient to overtake the target 76, the torpedo will ultimately strike and explode against the target. It is clear also that no amount of elusive maneuvering of the target in attempting to avoid the torpedo will be effective, since the torpedo will automatically correct its own course accordingly.

It has been stated that the radio sighting means mounted on the aerial torpedo may be employed to furnish the necessary information concerning the line of sight to the pilot in the carrier craft before release of the torpedo. The necessary equipment for this purpose is shown in Fig. 5.

As there shown, the operation of a cathode ray indicator tube 80 is placed under the control of the received pulses, as by lead 38', which is connected to lead 38 on the aerial torpedo. It will be remembered that a voltage pulse appears on lead 38 each time a reflected pulse is received by the reflector 15. The cathode ray tube 80, which is normally biased off, is biased on by the voltage pulse received on lead 38' and applied to its grid 81. Thus the electron stream is momentarily allowed to pass each time a reflected pulse is received.

The elevation and azimuth error signal voltages which appear on leads 6 and 7, respectively, of Fig. 1, are transmitted to the carrier craft, as by leads 6' and 7', and are applied to the vertical and horizontal deflecting plates 82 and 83, respectively, of the cathode ray tube 80.

In order to obtain a rough range indication there is superimposed upon the horizontal deflecting plates 83, as by lead 84, a rapidly oscillating voltage which is initiated at the time of the transmitted pulse and decreases in amplitude with time. This voltage may be obtained from a suitable "range wings" circuit 86 which is fed with pulses from the pulse transmitter 12 of Fig. 1, as by lead 85. A "range wings" circuit suitable for this purpose is fully described in previously mentioned copending application Serial No. 441,188.

The presentation appearing on the face of the cathode ray tube 80 is of the character shown in Fig. 6, wherein the position of the dot 87 with respect to the center of the face represents the angular orientation of the line of sight to the target with respect to the axis of the aerial torpedo. The length of the range wings 88 caused by the oscillating voltage from the "range wings" circuit 86, being inversely proportional to the delay time between transmission and reception of corresponding pulses by the reflector 15, provides an indication of the range or distance to the contemplated target, the length of these wings being inversely proportional to the range.

If the range is satisfactory, the pilot can then fly the carrier craft 75 in the correct direction to bring the spot 87 to the center of the face of the cathode ray tube 80, thereby aligning the axis of the aerial torpedo 1 with the line of sight. Upon release of the aerial torpedo, it will automatically maintain itself oriented along the line of sight and eventually strike the target, as previously explained.

The leads interconnecting the aerial torpedo 1 and the carrier aircraft 75 may each be terminated at a plug (not shown) which may be located on either the torpedo or the carrier craft, and which is adapted to easily pull apart upon release of the aerial torpedo 1.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense. In particular, it will be understood that the principles of the invention are not limited to an aerial torpedo, it being ob-

vious that any explosive-bearing and steerable body, whether designed for navigation in the air, on land or on water, could be equipped with apparatus similar to that disclosed in the present application.

What is claimed is:

1. In a device of the character described comprising a glider aircraft bearing a high explosive charge and equipped with elevator and rudder control surfaces for orientation of said craft in elevation and azimuth respectively, a radiant energy reflected-pulse radio system for defining a line of sight to a target, said system including means for generating periodic pulses of electromagnetic energy, a reflector for directly radiating said energy pulses into space in a fan-shaped beam along the axis of said reflector, said reflector axis making a small angle with the craft axis, means for rotating said reflector about the craft axis, whereby a solid conical angle of space is scanned with said energy, means for receiving the corresponding energy pulses reflected from a target located within said conical angle and means for interpreting the phase and amplitude of the variations in intensity of said reflected pulses and for producing elevation and azimuth signal voltages corresponding to the elevational and azimuthal components, respectively, of the angular displacement of the line of sight to the target with respect to the craft axis, servo control means for actuating said elevator control surface in response to said elevation signal voltage, and additional servo control means for actuating said rudder control surface in response to said azimuth signal voltage, whereby the orientation of said craft is continuously maintained coincident with the line of sight to said target.

2. An aerial torpedo, as claimed in claim 1, wherein said glider aircraft is also equipped with aileron control surfaces and a control device for operating said surfaces, said control device being actuated from said rudder servo control means, whereby the proper angle of bank is provided during turning of the craft.

3. Apparatus for striking a stationary or moving target with a high-explosive charge, comprising, in combination, a target-seeking glider torpedo containing said explosive, sighting means for defining a line of sight to a target mounted on said torpedo for continuously obtaining error signals indicative of the non-coincidence of the axis of said torpedo with respect to the line of sight to said target, indicating means responsive to said error signals, for initially aligning the torpedo axis prior to release with the line of sight, and automatic positioning means responsive to said error signals for continuously maintaining the axis of said torpedo directed on the sighted target after the release of said torpedo.

4. Apparatus for striking a stationary or moving target with a high-explosive charge, comprising a target seeking glider torpedo containing said explosive, radio sighting means for defining a line of sight to a target mounted on said torpedo including generating means for producing periodic pulses of electromagnetic energy, directive radiating means for projecting said energy pulses into a solid conical angle of space, the axis of said conical angle coinciding with the axis of said torpedo, means for receiving the corresponding energy pulses reflected from a target located within said solid angle and means for interpreting the variations in intensity of said reflected energy and producing voltage signals proportional to the angular deviation of the line of sight to

said target with respect to the orientation of said torpedo, indicating means responsive to said voltage signals, for aligning the torpedo axis initially and prior to release with the line of sight, and automatic positioning means responsive to said voltage signals for continuously maintaining the axis of said torpedo coincident with the line of sight to the target after release of said torpedo.

5. Apparatus, as claimed in claim 4, wherein said indicating means consists of a cathode ray tube, said voltage signals being applied to the horizontal and vertical deflecting plates of said tube, and further including means responsive to the time delay between said radiated pulses and the corresponding reflected pulses for providing on said cathode ray tube an indication of target range.

6. A self-controlled projectile adapted to steer itself into a stationary or moving target, comprising a steerable projectile, radio sighting means comprising generating means for producing periodic pulses of electromagnetic energy mounted on said projectile, directive radiating means for projecting said energy into a solid conical angle of space, means for receiving the corresponding energy pulses reflected from a target located within said solid angle, and means for interpreting the variations in intensity of said reflected energy and producing voltage signals proportional to the angular displacement of the line of sight to said target with respect to the axis of said radiating means, and automatic control means responsive to said signal voltages for continuously realigning the axis of said radiating means with the line of sight.

7. An aerial torpedo adapted to steer itself into and explode against a predetermined target, comprising a glider aircraft carrying an explosive charge, a radio sighting means comprising generating means for producing periodic pulses of electromagnetic energy, directive radiating means for projecting said energy pulses into a solid conical angle of space, the axis of said conical angle coinciding with the axis of said glider, means for receiving the corresponding energy pulses reflected from a target located within the solid angle, and means for interpreting the variations in intensity of said reflected energy and producing voltage signals proportional to the angular deviation of the line of sight to said target with respect to the orientation of said glider, and automatic control means responsive to said signal voltages for continuously reorienting said glider into coincidence with said line of sight.

8. A target seeking torpedo of the glider type, means mounted thereon for defining a line of sight to a target including an antenna, a transmitter therefor for projecting spaced signal impulses toward a target, a receiver operatively connected with the antenna responsive to said impulses when reflected back to the antenna from a target, an indicating device controlled by the receiver responsive to the received reflected impulses to aid in initially positioning the torpedo with reference to a target, and means controlled by the receiver in accordance with the reflected impulses on the launching of the torpedo for guiding the latter towards the target.

9. A target seeking torpedo comprising a glider aircraft bearing a high explosive charge and equipped with elevator and rudder control surfaces for orientation of said aircraft in elevation and azimuth respectively, radio sighting means mounted on the aircraft for defining a line of sight to a target including a rotary antenna, an

impulse transmitter and a receiver for receiving the transmitted impulses on reflection from the target, means jointly controlled by the receiver and the antenna according to the instantaneous angular position thereof for continuously obtaining error signal voltages indicative of the elevational and azimuth components, respectively, of the line of sight to the target with respect to the orientation of the axis of said aircraft, servo control means responsive to said elevation error signal voltage operating on said elevator control surface to orient the axis of said aircraft into coincidence with said line of sight in elevation, additional servo control means responsive to said azimuth signal voltage operating on said rudder control surface for orienting the axis of said aircraft into coincidence with said line of sight in azimuth, aileron control surfaces for the aircraft, and a control device for operating the latter surfaces actuated from the rudder servo control means, whereby the proper angle of bank is provided during turning of the aircraft.

WALDEMAR A. AYRES.

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Certificate of Correction

Patent No. 2,448,007.

August 31, 1948.

WALDEMAR A. AYRES

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 9, line 7, claim 1, strike out the word "In"; same line, for "a device" read *A device*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of April, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.